calculating the current end effector path;

generating a velocity profile of the end effector;

calculating an end effector velocity vector;

solving an inverse of the kinematic problem at velocity level;

[transfoming] transforming joint velocities into motor velocities; and

communicating the motor velocities to the motors.

Cancel Claim 8.

REMARKS

The Office Action dated June 16, 1997 has been carefully considered. In response to the Action, applicants have amended the application. The applicants request that the Examiner consider the following remarks, and then pass the application to allowance.

Applicants are grateful for the Examiner's suggestions for obviating the 35 U.S.C. 112, second paragraph rejections. The suggested corrections have been made where necessary.

Claims 1, 2, 8, 10 and 31 were rejected for *obviousness* under *Cunningham et al.* (4,433,382) in view of *Brien* (5,604,677). The Examiner stated that:

> Cunningham et al. discloses a two link and wrist robotic arm. Each movable joint has feedback to the controller and the wrist has three degrees of motion. Cunningham et al. does not disclose linear motion about the closest joint connection. Brien discloses a robot prealigner which is capable of performing x motion at the location of the link/base connection. It would have been obvious to one of ordinary skill in the art at the time the invention was made to have modified the controller of Cunningham et al. to provide linear motion at the base because Brien teaches that this motion allows the robot to reach an extended work area.

Applicants respectfully submit that a crucial element of their invention as claimed is absent from the teachings of *Cunningham et al.* and *Brien*. Specifically, the cited references do not show the use of a "means for monitoring and controlling the Y-motion such that the end effector can be moved in a straight line which is not restricted to the radial direction." (Claims 1 and 10, last paragraph). This claimed non-radial straight line motion enables applicants' robotic arm to approach and withdraw from multiple target regions which are linearly arranged, obviating the need to configure the work area circumferentially around the robotic arm. In this manner, an assembly-line type progression of the targets past the robotic arm is made possible, greatly speeding up the production process in which the robotic arm is employed.

Applicants' invention enables the simultaneous operation of multiple robotic arms performing coordinated tasks on products moving through shared work stations. Such shared work stations are not possible in the prior art because the operating zone of the prior art robotic arms is restricted, due to the limited radial motion of the robotic arm, to a circumferrential region which can only be accessed by a centrally located robotic arm. Such central location of the robotic arm by definition excludes the presence of more than one arm and precludes the efficient multi-arm arrangement contemplated by applicants' invention. The prior art neither teaches nor suggests applicants' advancement, which is claimed directly in Claims 1-7, 10-14 and indirectly in Claims 32, 36 and 40.

Claims 3-5, 11-13, 32 and 33 were rejected for *obviousness* under *Cunningham et al.* in view of *Brien* and Maydan et al. (4,951,601). The Examiner stated that:

> Cunningham et al. discloses a multiple linked robotic arm which may be modified according to the teachings of Brien to use linear base motions as discussed above but neither of these references disclose work stations which operate in conjunction with linear or conveyor processing systems. Maydan et al. discloses a wafer processing system that picks wafers from a loading area consisting of arrays of horizontally and vertically placed wafers. Since the tray holding wafers may move this is similar to a conveyor system. It

> would have been obvious to one of ordinary skill in the art at the time the invention was made to have further modified the controller of Cunningham et al. to provide horizontally located items for the system to operate on because Maydan et al. teaches that this is an efficient method of providing the wafers to the processing system.

As discussed above, applicants' invention permits the use of multiple robotic arms. In contradiction, any combination and modification of *Cunningham et al.* in view of *Brien* and *Maydan et al.*, even if properly motivated, would not achieve applicants' claimed invention because *Maydan et al.* shows that movement of products is restricted to a tangential direction relative to the accessible perimeter of the robotic arm. The robotic arm in *Maydan et al.* is thus still plagued by the limitation that it can only access products that are at a radial location from the arm's rotational axis, even when these products are being moved on a conveyer belt. Such a restriction does not permit of shared work stations and simultaneous operation of multiple robotic arms in the efficient and novel manner claimed by applicants. This novel feature of applicants' invention is also claimed in: Claims 3 and 11 in the form of the "set of cassettes arranged in a substantially straight line" in combination with a non-radial straight line motion of the end effector; in Claims 4, 32, 36 and 40 in the form of the cassettes that "are not all radially accessible to the end effector"; in Claim 5 in the form of the shared work stations, in Claim 7 in the form of the additional end effector that "can be moved in a straight line which is not restricted to the radial direction"; and in Claims 13, 33, 37 and 41 in the form of a plurality of arms sharing a common reach. These limitations, which are supported and discussed extensively in the specification, are absent from the prior art of record and serve to patentably distinguish applicants' invention from the prior art.

Claims 6, 14, 34 and 39-43 were rejected for *obviousness* under *Cunningham et al.* in view of *Brien*, *Maydan et al.* and *Poduje et al.* (5,456,561). The Examiner stated that:

> Cunningham et al. discloses a multiple linked robotic arm which may be modified according to the teachings of Brien to use linear base motions and according to the teachings of Maydan et al. to provide wafers horizontally as discussed above but none of these references disclose sensing the wafer alignment and correcting the alignment as needed. Poduje et al. discloses a robot wafer alignment device that senses misalignments and corrects them. It would have been obvious to one of ordinary skill in the art at the time the invention was made to have further modified the controller of Cunningham et al. to provide wafer alignment because Poduje et al. teaches that this allows the wafer position to be corrected.

Applicants' invention differs from the above-cited references, applied singularly or in combination, in that the measurements and adjustments of applicants' claimed invention are effectively made "on-the-fly," during transport of the product, whereas *Poduje et al.* measures the misalignment in a special sequence of steps distinct from the transport procedure itself. This special sequence of steps interrupts the flow of the production process and involves at least the placement of the wafer on the vacuum chuck 52 for rotation and measurement of misalignment. Subsequently, the wafer is either aligned by the vacuum chuck and then picked up by the robotic arm, or is picked up and aligned by the robotic arm itself. Both cases introduce additional steps which slow down the production procedure. Moreover, as *Poduje et al.* effectively admits by implication in column 4, lines 4-5, in the latter case where the alignment is performed by the robotic arm itself, certain limitations are encountered because, unlike the present invention, *Poduje et al.* does not teach yaw (Y) axis motion (Claims 6, 14, 34 and 39-43), roll (E) axis motion (Claims 34 and 43), and pitch (J) axis motion (Claims 39 and 43), and these omissions preclude correction of certain misalignments which applicants' claimed invention overcomes. For this reason at least, Claims 6, 14, 34 and 39-43, along with Claims 31-34 and 35-38, which also claim the same measurement and alignment feature, are allowable over the prior art of record.

The combination of the above references, even if properly made, also fails to address the issue of "jerky" motions which the present invention's yaw capability

resolves. As can be seen by the path trace indicated by the broken line in FIG. 1 of *Poduje et al.*, the motion of wafer 22 and hand 18 is discontinuous and involves a series of discrete motions which introduce various starts and stops which deleteriously affect the alignment of the wafer and the longevity of the robotic arm, thereby increasing production costs.

Claim 9 was rejected for *obviousness* under *Cunningham et al.* in view of *Brien*, *Maydan et al.*, *Poduje et al.*, *Ueyama et al.*, and *Miyake et al.* (5,157,315). The Examiner stated that:

> Cunningham et al. discloses a multiple linked robotic arm which may be modified according to the teachings of Brien to use linear base motions and according to the teachings of Maydan et al. to provide wafers horizontally and according to the teachings of Poduje et al. to provide wafer alignment when errors are detected and according to the teachings of Ueyama et al. to provide reversible tool end effectors as discussed above but none of these references disclose tracking the position of the end effector using kinematics. Miyake et al. discloses a robotic controller that controls the robotic arm using kinematics. it would have been obvious to one of ordinary skill in the art at the time the invention was made to have further modified the controller of Cunningham et al. to use kinematics to control the arm because Miyake et al. teaches that this allows the controller to precisely control the position and orientation of the end effector while moving the arm.

Claim 9 has been amended to include the limitations of Claim 8 and is now in independent form. Unlike the above-cited references, Claim 9 includes the limitations of "continuously generating the desired position, orientation, velocity, acceleration and jerks of the end effector . . . solving a direct kinematic problem at a position level by calculating the position and the orientation of the end effector, and an end effector tracking error . . . generating a velocity profile of the end effector; calculating an end effector velocity vector; solving an inverse of the kinematic problem at velocity level; transforming joint velocities into motor velocities; and communicating the motor velocities to the motor." These limitations are neither taught nor suggested by *Miyake et*

al., which is restricted to an interpolation technique, and for this reason it is submitted that Claim 9 contains novel subject matter and is patentable over the prior art of record.

Claims 15-17, 19-21, 23-25 and 27-29 were rejected for *obviousness* under *Cunningham et al.* in view of *Brien*, *Maydan et al.*, *Poduje et al.*, *Ueyama et al.*, *Miyake et al.* and *Kishi et al.* (4,706,000). The Examiner stated that:

> Cunningham et al. discloses a multiple linked robotic arm which may be modified according to the teachings of Brien to use linear base motions and according to the teachings of Maydan et al. to provide wafers horizontally and according to the teachings of Poduje et al. to provide wafer alignment when errors are detected and according to the teachings of Ueyama et al. to provide reversible tool end effectors and according to the teachings of Miyake et al. to provide kinematics controls as discussed above but none of these references disclose using two arms in a parallelogram arrangement. Kishi et al. discloses a parallelogram robot arm controller. It would have been obvious to one of ordinary skill in the art at the time the invention was made to have further modified the controller of Cunningham et al. to use parallelogram links because these links are much stronger than single element links.

Applicants respectfully submit that the above references, singularly or in combination, fail to show presently claimed arrangement. Specifically, applicants' invention does not involve a "parallelogram" arrangement. Rather, applicants claim, inter alia, "two pairs of linkages . . . the distal end portion of the distal link of each of the pairs of linkages being pivotally mounted at a distal axis to one another . . ." (Claim 15, first paragraph). Such an arrangement is not of the parallelogram type and provides numerous advantages thereover. One advantage is that the links in such an arrangement are capable of being mounted such that their motion can be extended to opposing sides of their mounting structure--in other words, they can be designed to retract over and clear the mounting structure, and then operate on the opposite side of the mounting structure, without being obstructed thereby, greatly increasing their movement range and versatility. The third paragraph of Claim 15 claims this feature, which is neither suggested by nor

obvious from the prior art. For this reason at least, Claim 15 and Claims 16-30 dependent therefrom are patentably distinct from the prior art of record.

The references cited but not relied upon in the Office Action have been noted. They are not considered pertinent to the patentability of applicants' invention.

In view of the preceding discussion, applicants respectfully urge that the claims of the present application define patentable subject matter and should be passed to allowance. Such allowance is respectfully solicited.

Respectfully submitted,
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